

Constraining New Physics with D meson decays

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The standard model (SM) prediction for the leptonic $D_s \rightarrow \ell \nu_\ell$ decay is slightly smaller than the world average experimental measurement, while the semileptonic SM branching ratios of the D^0 and D^+ meson decays are higher than the world average. Using the observed leptonic and semileptonic branching ratios for the D meson decays, we performed a global analysis to constrain non standard interactions which mediate the $c\bar{s} \rightarrow l\bar{\nu}$ transition through generic Wilson coefficients that can be later apply to obtain the respective bounds over the relevant parameters for a huge variety of models beyond the standard model. In particular, we obtain significant bounds for the Two Higgs Doublet Model Type-II and Type III, the Left-Right symmetric model and Minimal Supersymmetric Standard Model with explicit R-Parity violation. We found more restrictive or similar bounds as previous analysis showing the potential of these type of analysis to constrain new physics. Taking into account the reported error on the form factors, we show it is not possible to reconcile our constraints for the Two Higgs Doublet Model Type-II at 68% confidence level with previous observations.

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Introduction. In spite of the Standard Model (SM) success, now favored by the probable recent discovery of the Higgs boson [1, 2], the search of a more fundamental theory at an energy scale bigger than the electroweak scale is still open. Interestingly, low energy scale experiments may shed some light in the search for such fundamental theory due to their possibility of getting high statistics and hence indirect observables of New Physics (NP). We will use D meson decays as an illustration. Contrary to B meson physics, charmed hadronic states are in the unique mass range of $O(2\text{ GeV})$, which allows for strong non perturbative hadronic physics [3]. Moreover, the calculations for the relevant form factors, which parameterize all QCD effects within the hadronic state, have been improved significantly reaching a surprising precision [4].

At low energies, most of the extensions to the Standard Model reduce to an effective four Fermi interaction, usually called Non Standard Interaction NSI, that can be parameterized by a generic coefficient (Fig. 1). For the leptonic and semileptonic $\Delta C = \Delta S$ D meson decays, the new particle state should couple to the leptons and the second generation of quarks, leaving such effective interaction. Any kind of intermediate state, such as scalars, vectors or even tensors, are allowed. Examples are the Two Higgs Doublet Model Type-II (THDM-II) and Type III (THDM-III) [5], the Left-Right symmetric model (LR) and Minimal Supersymmetric Standard Model with explicit R-Parity violation (MSSM- \mathcal{R}) [6, 7], also illustrated in Fig. 1. In this work we make, for the first time, a global analysis including all possible non standard interactions, over generic coefficients that parameterize any NP effects in the $c\bar{s} \rightarrow l\bar{\nu}$ transition. We use the semileptonic $D^0 \rightarrow K^- l \nu$ and $D^+ \rightarrow \bar{K}^0 l^+ \nu$ decays and the leptonic decays of the D_s meson. In the past only the D_s leptonic decays were considered [8]

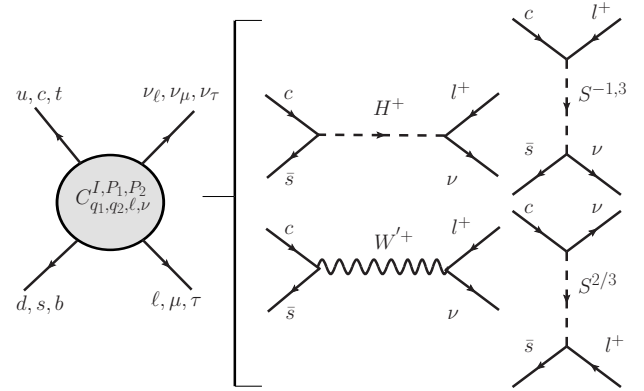


FIG. 1. Generic charged current non standard interaction between two quarks and the leptonic sector. Some Feynman diagrams for models beyond SM involving the $c\bar{s} \rightarrow l\bar{\nu}$ transition involved in D meson decays are shown.

and the possibility of using semileptonic decays was just mentioned in [9]. Furthermore, we use these obtained model independent constraints on some particular models, namely THDM-II and THDM-III, LR and MSSM- \mathcal{R} and show that it is enough to consider those coefficients to have reliable bounds on specific models.

Model Independent Analysis. The search of new physics effects in the leptonic and semileptonic processes of mesons has two sources of uncertainty that can not be separated; the non perturbative long-distance forces that bind quarks forming hadronic states and the determination of the free parameters of the SM, *i.e.* fermions masses and CKM matrix elements. The non-perturbative QCD effects are parameterized introducing form factors. On the other hand effective couplings that correspond to short distance interactions could receive non-standard contributions. Hence flavour-changing meson transitions

in the SM have at least two scales involved, the electroweak scale that is responsible of the flavour changing and the scale of strong interactions [10]. When NSI are considered, we assume that the new physics energy scale is higher than the electroweak scale, thus the operator product expansion formalism (OPE) [11] is suitable since it allows the separation between long-distance (low energy) and short-distance (high energy) interactions. In the OPE the degrees of freedom corresponding to higher energies scales are integrated out [12], resulting an effective Lagrangian theory where all high energy physics effects are parameterized by Wilson's coefficients, namely the effective couplings multiplying the operators of the Lagrangian. In this spirit, the most general non-standard effective Lagrangian for a semileptonic transition as the one illustrated in Fig. 1 is:

$$-\mathcal{L}_{NP} = \sum_{\substack{q_1, q_2, \ell, \nu \\ I=S, V, T \\ P_{1,2}=L, R}} C_{q_1 q_2 \ell \nu}^{I, P_1 P_2} (\bar{q}_1 \Gamma^I P_1 q_2) \cdot (\bar{\nu}_L \Gamma_I P_2 \ell), \quad (1)$$

where the indexes q_1 and q_2 represent down-type and up-type quarks respectively, ℓ is the charged lepton flavor and ν its corresponding neutrino. $P_{1,2}$ represent the chiral projectors $L = (1 - \gamma^5)/2$ and $R = (1 + \gamma^5)/2$. Here, the current operators Γ 's are determined by the Dirac field bilinears, namely: $\Gamma_S = 1$, $\Gamma_V = \gamma_\mu$ and $\Gamma_T = (i/2)[\gamma^\mu, \gamma^\nu]$. The dimensionless coefficients $C_{q_1 q_2 \ell \nu}^{I, P_1 P_2}$ have a clean interpretation: they are a measurement of how big can the NSI be as compared to the SM current, since they are weighted by the Fermi constant G_F . This parametrization technique enables us to test NSI when the experiments reach certain precision, and in particular to look for NP effects at low energies. We use this technique in a combined analysis of leptonic and semileptonic D meson decays to constrain scalar (S) and vectorial (V) NSI which conserve lepton flavor for a $c\bar{s} \rightarrow l\bar{\nu}$ transition. We shall not take into account the tensorial contribution in our global analysis, mainly because those tensorial NSI are expected to be relatively small compared to scalar and vectorial form factors due to the lack of tensorial resonance with these quantum numbers at D meson scale. Hence, the relevant parameters with the above considerations are: $C_{scl\nu}^{V, LL}$, $C_{scl\nu}^{V, RL}$, $C_{scl\nu}^{S, RR}$ and $C_{scl\nu}^{S, LR}$. For the purpose of this work, we will consider them as real parameters, because the observables we are interested in are more sensitive to the real contribution rather than the imaginary part.

The decay rate of $D_s \rightarrow \ell \nu_\ell$ including the SM Lagrangian plus the NSI Lagrangian eq. 1, is thus given by

$$\Gamma_{D_s \rightarrow \ell \nu} = \frac{|G_F f_{D_s} (M_{D_s}^2 - m_\ell^2)|^2}{8\pi M_{D_s}^3} |V_{cs} m_l + \frac{m_l (C_{scl\nu}^{V, LL} - C_{scl\nu}^{V, RL})}{2\sqrt{2}} + \frac{M_{D_s}^2 (C_{scl\nu}^{S, RR} - C_{scl\nu}^{S, LR})}{2\sqrt{2}(m_c + m_s)}|^2. \quad (2)$$

TABLE I. Theoretical and experimental branching ratios

i	Decay	Theoretical	Experimental
1	$D^0 \rightarrow K^- e^+ \nu_e$	3.639%	$(3.55 \pm 0.04)\%$
2	$D^0 \rightarrow K^- \mu^+ \nu_\mu$	3.559%	$(3.30 \pm 0.13)\%$
3	$D^+ \rightarrow \bar{K}^0 e^+ \nu_e$	9.325%	$(8.83 \pm 0.22)\%$
4	$D^+ \rightarrow \bar{K}^0 \mu^+ \nu_\mu$	9.099%	$(9.2 \pm 0.6)\%$
5	$D_s^+ \rightarrow \tau^+ \nu_\tau$	5.106%	$(5.43 \pm 0.31)\%$
6	$D_s^+ \rightarrow \mu^+ \nu_\mu$	5.235×10^{-3}	$(5.90 \pm 0.33) \times 10^{-3}$

On the other hand, the semileptonic $D^0 \rightarrow K^- \ell^+ \nu_\ell$ and $D^+ \rightarrow \bar{K}^0 \ell^+ \nu_\ell$ decay rates are given by

$$\frac{d\Gamma_{D \rightarrow K \ell \nu_\ell}}{dE_K} = \frac{G_F^2 m_D}{(2\pi)^3} \sqrt{E_K^2 - m_K^2} \left(1 - \frac{m_\ell^2}{q^2}\right)^2 \left\{ (E_K^2 - m_K^2) \frac{2q^2 + m_\ell^2}{3q^2} |(V_{cs}^* + G_V) f_+(q^2)|^2 + \frac{|(m_D^2 - m_K^2) q f_0(q^2)|^2}{4m_D^2} \left| \frac{m_\ell}{q^2} (V_{cs}^* + G_V) + \frac{G_S}{m_c - m_s} \right|^2 \right\}, \quad (3)$$

where in the later expression we have defined $G_V = (C_{scl\nu}^{V, LL} + C_{scl\nu}^{V, RL})/2\sqrt{2}$ and $G_S = (C_{scl\nu}^{S, RR} + C_{scl\nu}^{S, LR})/2\sqrt{2}$. Other constants involved in Eqs. (2, 3) are: G_F the Fermi constant, $m_\ell, m_c, m_s, m_K, m_{D_s}, m_D$ the masses of the leptons, charm and strange quarks, the Kaon and D meson respectively as reported by PDG [13]. The transferred energy is $q^2 = m_D^2 + m_K^2 - 2m_D E_K$ and E_K is the final energy of the Kaon meson. Its allowed energy is $m_K < E_K < (m_D^2 + m_K^2 - m_\ell^2)/2m_D$. In addition to those constants, other physical inputs are:

The CKM element V_{cs} . The direct measurement of this element comes precisely from the D meson decay measurement. Since we are interested in possible signals of NP in those decays, we use instead the average value from PDG, i.e. $V_{cs} = 0.97344$.

Hadronic form factors. For the leptonic decay, the decay constant f_{D_s} is defined by $\langle 0 | \bar{s} \gamma_\mu \gamma_5 c | D_s(p) \rangle = i f_{D_s} p_\mu$. It has been computed with a precision of the order of 2% by the HPQCD collaboration [14]. The reported value is $f_{D_s} = 248 \pm 2.5$ MeV. On the other hand, less is known about $f_0(q^2), f_+(q^2)$, which are defined via $\langle K | \bar{s} \gamma^\mu c | D \rangle = f_+(q^2)(p_D + p_K - \Delta)^\mu + f_0(q^2)\Delta^\mu$, with $\Delta^\mu = (m_D^2 - m_K^2)q^\mu/q^2$, and $\langle K | \bar{s} c | D \rangle = (m_D^2 - m_K^2)/(m_c - m_s)f_0(q^2)$. We use the parametrization [15]

$$f_+(q^2) = \frac{f_+(0)}{(1 - \tilde{q}^2)(1 - \alpha \tilde{q}^2)}, \quad f_0(q^2) = \frac{f_+(0)}{(1 - \tilde{q}^2/\beta)}, \quad (4)$$

where $\tilde{q}^2 = q^2/m_{D_s}^2$. $f_+(0)$ has been computed using three-flavor lattice QCD calculations. It has been found $f_+(0) = 0.73 \pm 0.03 \pm 0.07$ and $\alpha = 0.50 \pm 0.04$ and $\beta = 1.31 \pm 0.07$ [4].

We will ignore all radiative corrections since they are expected to be below the 1% [16]. Once all those ele-

ments are incorporated, we compute the theoretical decay rates predicted by the SM $\Gamma_{D_s \rightarrow \ell \nu}^{th}$, $\Gamma_{D^0 \rightarrow K + \ell - \nu_\ell}^{th}$ and $\Gamma_{D^+ \rightarrow \bar{K}^0 \ell + \nu_\ell}^{th}$ fixing Wilson's coefficient to zero. From the experimental side, D_s leptonic decays have been measured by a number of experiments, namely CLEO [17] and Belle [18]. Semileptonic decays have been observed with an integrated luminosity of 818 pb^{-1} [19]. From those measurements it is possible to extract the lifetimes for the mesons. They result to be $\tau_{D^0} = (410.1 \pm 1.5) \times 10^{-15} \text{ s}$, $\tau_{D^+} = (1040 \pm 7) \times 10^{-15} \text{ s}$, and $\tau_{D_s} = (500 \pm 7) \times 10^{-15} \text{ s}$. It is now possible to compute our theoretical branching ratio (BR) just as $\mathcal{B}_i^{th} = \Gamma_i^{th} \tau_i$, i labeling the six different processes involving D decays. Our results are listed in table I as well as the experimental BRs as reported by PDG [13]. Note that there is a mismatch between the theoretical and experimental branching ratios: the leptonic $D_s \rightarrow \ell \nu_\ell$ decay is slightly smaller than the world average experimental measurement, while the semileptonic SM branching ratio of the D^0 and D^+ meson decays are higher than the world average. Let us suppose that the disagreement comes from new physics effects, hence we can compute the range of the Wilson coefficients to match the theory and the experiment. In order to do so, we perform a simple χ^2 analysis, with $\chi^2 = \sum_i (\mathcal{B}_i^{th} - \mathcal{B}_i^{exp})^2 / \delta \mathcal{B}_i^2$. Here $\delta \mathcal{B}$ is the error, where, in addition to the experimental error, we have assumed an extra 4% theoretical error added in quadratures to the experimental error for the leptonic decays, while for the semileptonic decays we have included an extra 10% theoretical error added in quadratures as well. The main source of errors comes from the form factors. The reported error in f_{D_s} induces a 2% error in the theoretical leptonic branching ratio. That is, we are adding the double error in order to be conservative in our bounds. On the other hand, the reported error in the lattice determination of $f_0(q^2)$ and $f_+(q^2)$ leads to a 7% error in the theoretical semileptonic branching ratio. Again, we have rounded the error to 10% to be conservative. The results for the relevant Wilson coefficients are listed in Table II. The first set corresponds to universal NSI, that is, flavor independent interactions. In this case there are four coefficients: $C_{scl\nu}^{V,LL}$, $C_{scl\nu}^{V,RL}$, $C_{scl\nu}^{S,RR}$ and $C_{scl\nu}^{S,LR}$. Some models may induce Vector as well as scalar NSI at the same time, hence, we report model independent constraints by varying all four parameters at a time. We also report the bounds obtained by varying only one parameter at a time, that is, the most restricted bound. Other models may depend on the flavor of the lepton involved. Since we have only six \mathcal{B}^{th} s, we can perform the χ^2 analysis only if we assume scalar NSI or vectorial NSI at a time. In each case, for electron NSI, we use the channels $i = 1, 3$, for muon $i = 2, 4, 6$ and for the tau, only a fit can be performed with $i = 5$; channel i as shown in Table I. Results for both cases, scalar and vectorial flavor dependent NSI are listed in Table II.

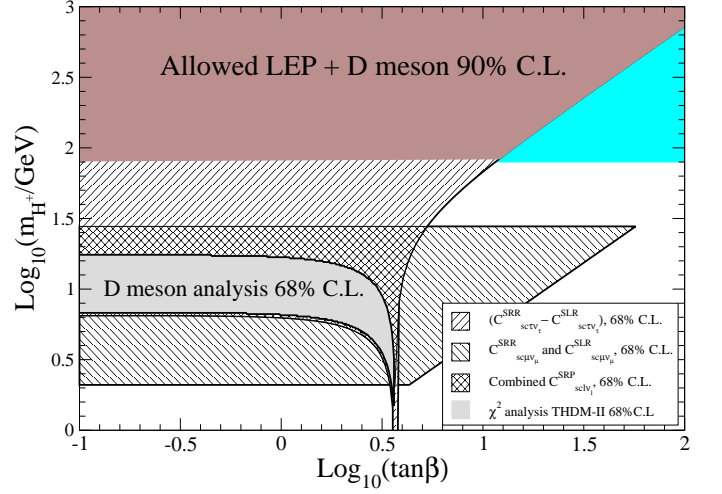


FIG. 2. Allowed regions for $\tan \beta$ and the mass of the charged Higgs to be consistent with the D meson decays at 68% C.L. obtained by using the Wilson coefficient and by a complete χ^2 analysis of the BRs. The LEP limit on the mass of a charged Higgs is also plotted [25].

Model Dependent Analysis: Let us make explicit the relation between the Wilson coefficient and some specific models.

Two Higgs doublet model (THDM): It is one of the simplest and economical extensions of the SM, see [20],[21] for a review. THDM introduces an additional scalar doublet that induces scalar charged currents (H^\pm), two neutral scalar fields and a pseudoscalar neutral field (h^0 , H^0 and A^0). For D meson decays, the only two parameters involved are the new scalar mass (m_{H^\pm}) and the ratio of the vacuum expectation values $\tan \beta$ of the two Higgs doublets. At low energies, the Lagrangian for THDM, in the Higgs basis for the charge scalars and the mass basis for fermions, is given by [22]

$$-\mathcal{L}_{H^\pm} = \sqrt{2}/v H^\pm [V_{u_i d_j} \bar{u}_i (m_{u_i} X P_L + m_{d_j} Y P_R) d_j + m_\ell Z \bar{\nu}_L \ell_R] + \text{H.c.} \quad (5)$$

with X, Y, Z functions of m_{H^\pm} and $\tan \beta$ different for different versions of THDM, and the Wilson coefficients will be given by

$$\frac{C_{scl\nu}^{S,RR}}{2\sqrt{2}} = V_{cs}^* \frac{m_\ell m_c}{M_H^2} Z X, \quad \frac{C_{scl\nu}^{S,LR}}{2\sqrt{2}} = V_{cs}^* \frac{m_\ell m_s}{M_H^2} Z Y. \quad (6)$$

In particular, THDM-II has Natural Flavour Conservation, namely the suppression of Flavor Changing Neutral Currents (FCNC) at tree level, through a Z_2 symmetry [23]. Interesting bounds have been obtained with meson decay experiments [24] and recently LEP has reported a lower bound on the mass of the charged Higgs of 80 GeV [25]. For THDM-II, $X = \cot \beta$, $Y = Z = \tan \beta$. Now we will illustrate the effectiveness of our model independent

Universal non standard interactions				
	4 pars. at-a-time 68% C.L.	4 pars. at-a-time 90% C.L.	1 par. at-a-time 68% C.L.	1 par. at-a-time 90% C.L.
$C_{scl\nu}^{V,LL}$	$[-0.748, 0.332]$	$[-0.840, 0.362]$	$[-0.014, 0.086]$	$[-0.048, 0.118]$
$C_{scl\nu}^{V,RL}$	$[-0.876, 0.051]$	$[-0.969, 0.120]$	$[-0.142, -0.039]$	$[-0.175, -0.006]$
$C_{scl\nu}^{S,RR}$	$[-1.17, 1.10]$	$[-1.24, 1.11]$	$[0.003, 0.010]$	$[1.8 \times 10^{-4}, 0.013]$
$C_{scl\nu}^{S,LR}$	$[-1.152, 1.130]$	$[-1.173, 1.178]$	$[-0.010, 2.7 \times 10^{-3}]$	$[-0.013, -2.1 \times 10^{-4}]$
Flavor dependent scalar non standard interactions				
	$C_{scl\nu}^{S,P_1,P_2} \in \Re^+ \text{ 68\% C.L.}$	$C_{scl\nu}^{S,P_1,P_2} \in \Re^+ \text{ 90\% C.L.}$	$C_{scl\nu}^{S,P_1,P_2} \in \Re \text{ 68\% C.L.}$	$C_{scl\nu}^{S,P_1,P_2} \in \Re \text{ 90\% C.L.}$
$C_{scl\nu_e}^{S,RR} + C_{scl\nu_e}^{S,LR}$	$[0.0, 0.465]$	$[0.0, 0.658]$	$[-0.468, 0.467]$	$[-0.661, 0.660]$
$C_{scl\nu_\mu}^{S,RR}$	$[3.9 \times 10^{-4}, 0.130]$	$[0.0, 0.134]$	$[-1.23, 0.990]$	$[0.312, .234]$
$C_{scl\nu_\mu}^{S,LR}$	$[0.0, 0.147]$	$[0.0, 0.150]$	$[-1.23, 0.990]$	$[0.312, .234]$
$C_{scl\nu_\tau}^{S,RR} - C_{scl\nu_\tau}^{S,LR}$	$[-8.79 \times 10^{-3}, 0.116]$	$[-5.08 \times 10^{-2}, 0.154]$	$[-8.79 \times 10^{-3}, 0.116]$	$[-5.08 \times 10^{-2}, 0.154]$
Flavor dependent vectorial non standard interactions				
	$C_{scl\nu}^{V,P_1,P_2} \in \Re^+ \text{ 68\% C.L.}$	$C_{scl\nu}^{V,P_1,P_2} \in \Re^+ \text{ 90\% C.L.}$	$C_{scl\nu}^{V,P_1,P_2} \in \Re \text{ 68\% C.L.}$	$C_{scl\nu}^{V,P_1,P_2} \in \Re \text{ 90\% C.L.}$
$C_{scl\nu_e}^{V,LL} + C_{scl\nu_e}^{V,RL}$	$[0.0, 0.056]$	$[0.0, 0.111]$	$[-0.149, 0.041]$	$[-0.216, 0.101]$
$C_{scl\nu_\mu}^{V,LL}$	$[0.0, 0.131]$	$[0.0, 0.178]$	$[-0.057, 0.168]$	$[-0.107, .213]$
$C_{scl\nu_\mu}^{V,RL}$	$[0.0, 0.046]$	$[0.0, 0.082]$	$[-0.225, 3.0 \times 10^{-3}]$	$[-0.270, 0.045]$
$C_{scl\nu_\tau}^{V,LL} - C_{scl\nu_\tau}^{V,RL}$	$[-0.014, 0.184]$	$[-0.083, 0.245]$	$[-0.014, 0.184]$	$[-0.083, 0.245]$

TABLE II. Model independent constraints at 90% and 68% C.L. We have assumed a 10% error of the total semileptonic branching ratio and an extra 4% of the leptonic branching ratio, as a theoretical error, which was added in quadratures to the experimental error.

bounds once we apply them to the Wilson coefficients of THDM, eqs. 6. There is a flavor dependence coming from the mass of the leptons involved. Since this is an scalar interaction, we can use the bounds on flavor dependent scalar NSI. From $C_{scl\nu_\tau}^{S,RR} - C_{scl\nu_\tau}^{S,LR}$ we get the region $-1.8 \times 10^{-3} \text{ GeV}^{-1} < (m_c - m_s \tan^2 \beta)/M_H^2 < 0.023 \text{ GeV}^{-1}$ at 68% C.L., which gives the outer region of an ellipse and the inner region of an hyperbole in the plane $(m_H, \tan \beta)$ illustrated in Fig. 2. Furthermore, with the help of the respective bounds for $3.9 \times 10^{-4} < C_{scl\nu_\mu}^{S,RR} = 2\sqrt{2}V_{cs}^* \frac{m_\mu}{M_H^2} m_c < 0.130$ (68% C.L.), an upper limit on M_H is obtained. Together with the bounds for $C_{scl\nu_\mu}^{S,LR}$ the trapezoidal region in Fig. 2 is obtained. The combination of these regions are in excellent agreement with the region obtained by a complete χ^2 analysis, which is plotted in Fig. 2 in a shadow grey area. This agreement illustrates the effectiveness of using generic Wilson coefficient to constrain the relevant parameters of models beyond the SM. For completeness, the THDM-III correspond to the following definitions: $X = \cot \beta - \frac{\text{csc} \beta}{\sqrt{2\sqrt{2}G_F}} m_c^{-1} \left(\tilde{Y}_{1,22}^u + \frac{V_{us}}{V_{cs}} \tilde{Y}_{1,21}^u + \frac{V_{ts}}{V_{cs}} \tilde{Y}_{1,23}^u \right)$, $Y = \tan \beta - \frac{\text{sec} \beta}{\sqrt{2\sqrt{2}G_F}} m_s^{-1} \left(\tilde{Y}_{2,22}^d + \frac{V_{cd}}{V_{cs}} \tilde{Y}_{2,12}^d + \frac{V_{ch}}{V_{cs}} \tilde{Y}_{2,32}^d \right)$ and $Z = \tan \beta - \frac{\text{sec} \beta}{\sqrt{2\sqrt{2}G_F}} m_\ell^{-1} \tilde{Y}_{2,\nu_\ell}^\ell$, where $\tilde{Y}_{a,ij}^f$ are the Yukawa elements as were defined in [26, 27]. The corresponding bounds obtained via eqs. 6 for THDM-III are interesting since they show relations between $\tilde{Y}_{a,ij}^f$, β and the mass of the charged Higgs.

Left-right model: As an example of a pure vectorial

NSI, we will consider SM's extensions based on extending the SM gauge group including a gauge $SU(2)_R$ [28–31]. In this case, the Wilson coefficients, that can be deduced from [32], are : $-0.048 < C_{scl\nu}^{V,LL} = V_{cs}^* \sin^2 \xi ((M_W/M'_W)^2 - 1) < 0.118$ and $-0.175 < C_{scl\nu}^{V,RL} = V_{cs}^* g_R / (2g_L) \sin(2\xi) (1 - (M_W/M'_W)^2) < -0.006$ at 90% C.L., which is consistent with TWIST results [33, 34].

MSSM- \tilde{R} : R-Parity violating (RPV) superpotentials lead to flavor violating interactions in the leptonic and hadronic sector that are usually present in many models beyond the Standard Model. A vast majority of observables have been used to set the corresponding bounds to these effective couplings (for a complete review see [7] and references therein); in particular, for D meson decays [35–40]. We relate the corresponding Wilson coefficients constrained in the global analysis to the RPV couplings which constructively interfere with the Standard Model, i.e. through the exchange of a $-1/3$ electrically charged squark in a t-channel, which fixes the neutrino flavor. The only non-vanishing Wilson coefficient is $C_{scl\nu}^{V,LL} = 2\sqrt{2}V_{cs}/G_F \sum_k |\lambda'_{12k}|^2 / m_{d_R^{k*}}^2$. Using the conservative bounds for the model independent constraints (table II) we get the following constraints at 90% confidence level: $\sum_k |\lambda'_{12k}|^2 / m_{d_R^{k*}}^2 < 4.7 \times 10^{-7}$, $\sum_k |\lambda'_{22k}|^2 / m_{d_R^{k*}}^2 < 7.54 \times 10^{-7}$, $\sum_k |\lambda'_{32k}|^2 / m_{d_R^{k*}}^2 < 1.04 \times 10^{-7}$. Our bounds agree with those found in [39].

Conclusions. We performed a model independent analysis of the non standard interactions in the combined pro-

cesses $D_s \rightarrow \ell \nu_\ell$ and $D^0 \rightarrow K \ell \nu_\ell$, using the latest experimental measurements of the branching ratios compared to the theoretical expectations. We have found the corresponding bounds for the Wilson coefficients that parameterize the contribution of new physics as non standard interactions. Those constraints can be applied to any model of new physics. In particular we have used them to constrain the THDM-II, Type III, the Left-Right symmetric model and MSSM- \mathcal{R} . We found more restrictive or similar bounds as previous analysis, showing the potential of these type of analysis to constrain new physics. Taken into account the reported error on the form factors, we found that our results are in disagreement, at 68% C.L., with previous constraints on the Two Higgs Doublet Model Type-II coming from other processes [25].

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